

IT IS CLAIMED:

1. A method for treating a surface of a quartz substrate comprising:

preparing a quartz substrate to provide a working surface having an initial working surface roughness; and

ultrasonically acid-etching said working surface to increase the roughness of said working surface by at least about 10%.

2. A method for treating a surface of a quartz substrate as recited in claim 1 wherein preparing a quartz substrate includes obtaining a quartz substrate having an initial working surface roughness greater than about 10 Ra.

3. A method for treating a surface of a quartz substrate as recited in claim 2 wherein preparing a quartz substrate includes obtaining a quartz substrate having an initial working surface roughness of about 16 Ra.

4. A method for treating a surface of a quartz substrate as recited in claim 2 wherein preparing a quartz substrate includes roughening said initial working surface to a roughness greater than about 100 Ra by coarse grit blasting said working surface with a grit having mesh size no greater than about 100.

5. A method for treating a surface of a quartz substrate as recited in claim 4 wherein said roughening roughens said initial working surface to a roughness greater than about 300 Ra.

6. A method for treating a surface of a quartz substrate as recited in claim 1 wherein ultrasonically acid-etching increases the working surface roughness by at least about 25%.

7. A method for treating a surface of a quartz substrate as recited in claim 1 wherein ultrasonically acid-etching increases said working surface roughness by at least about 50%.

8. A method for treating a surface of a quartz substrate as recited in claim 1 further comprising:

grit blasting said working surface after ultrasonically acid-etching said working surface with a fine grit having a mesh size greater than about 100.

9. A method for treating a surface of a quartz substrate as recited in claim 8 wherein said fine grit has a mesh size greater than about 200.

10. A method for treating a surface of a quartz substrate as recited in claim 8 wherein said acid-etching is a first acid-etching and further comprising a second acid-etching of said working surface after fine grit blasting said working surface.

11. A method for treating a surface of a quartz substrate as recited in claim 10 wherein said first acid-etching removes substantially more material from

said working surface than said second acid-etching.

12. A method for treating a surface of a quartz substrate, said method comprising

ultrasonically acid-etching a substrate to substantially remove one or more cracks in a working surface of said substrate; and

subjecting said substrate surface to a final cleaning process which prepares said substrate for use.

13. A method for treating a surface of a quartz substrate as recited in claim 12 further comprising:

coarse grit blasting said working surface prior to ultrasonically acid-etching to produce a roughened surface having an average surface roughness (Ra) of between about 100 and about 400 Ra.

14. A method for treating a surface of a silicon-containing substrate as recited in claim 12 wherein said final cleaning process comprises:

contacting said substrate with an acidic solution selected from said group consisting of HF:HNO<sub>3</sub>:H<sub>2</sub>O and HF:H<sub>2</sub>O<sub>2</sub>:HNO<sub>3</sub>;

rinsing said substrate with deionized water;

ultrasonically treating said substrate in an ultrasonication deionized water bath;

drying said substrate with nitrogen to remove excess moisture; and

heating said substrate under a heat lamp or in an oven.

15. A method for treating a surface of a silicon-containing substrate as recited in claim 12 further comprising:

micro-roughening said surface of said substrate prior to said final cleaning process by:

(a) positioning a pressurized grit expulsion nozzle a predetermined distance from, and at an angle less than about 60° to, said substrate surface; and

(b) ejecting grit from said nozzle against said surface at a velocity sufficient to produce a micro-roughened surface.

16. A method for treating a surface of a silicon-containing substrate comprising:

immersing said substrate into a chemical solution to substantially remove a non-organic contaminant;

rinsing said substrate with deionized water; and

subjecting said substrate surface to a final cleaning process which prepares said substrate for use.

17. A method for treating a surface of a silicon-containing substrate comprising as recited in claim 16 wherein said chemical solution is a first chemical solution, and further comprising:

immersing said substrate into a second chemical solution to substantially remove an organic contaminant before immersing said substrate into said first chemical solution.

18. A method for treating a surface of a silicon-containing substrate as recited in claim 17 further comprising:

heating said substrate in a furnace at a high temperature to damage chemical bonds after immersing said substrate into said second chemical solution but before immersing said substrate in said first chemical solution.

19. A method for treating a surface of a silicon-containing substrate as recited in claim 16, wherein said final cleaning process comprises

contacting said substrate with an acidic solution selected from said group consisting of HF:HNO<sub>3</sub>:H<sub>2</sub>O and HF:H<sub>2</sub>O<sub>2</sub>:HNO<sub>3</sub>;

rinsing said substrate with deionized water;

ultrasonicated said substrate in an ultrasonication deionized water bath;

drying said substrate with nitrogen until substantially visually dry; and

heating said substrate under a heat lamp or in an oven.

20. A method for treating a surface of a silicon-containing substrate as recited in claim 16, wherein said second chemical solution is an organic solvent.

21. A method for treating a surface of a silicon-containing substrate as recited in claim 16, wherein said first chemical solution is an acidic solution comprising one or more of said group consisting of hydrofluoric acid, nitric acid and water.

22. A method for treating a surface of a silicon-containing substrate as recited in claim 16, further comprising:

micro-roughening said surface of said substrate, prior to said final cleaning process, including:

(a) positioning a pressurized grit expulsion nozzle a predetermined distance from, and at an angle less than about 60° to, said substrate surface; and

(b) ejecting grit from said nozzle against said surface at a velocity sufficient to produce a micro-roughened surface.

23. A method for treating a surface of a silicon-containing substrate as recited in claim 22 wherein said positioning comprises positioning said nozzle from said surface at a distance between about two inches to about ten inches.

24. A method for treating a surface of a silicon-containing substrate as recited in claim 23, wherein said positioning comprises positioning said nozzle from said surface at a distance equal to about six inches.

25. A method for treating a surface of a silicon-containing substrate as recited in claim 22, wherein said positioning comprises positioning said nozzle at an angle to said surface between about 40° and about 50°.

26. A method for treating a surface of a silicon-containing substrate as recited in claim 25, wherein said positioning comprises positioning said nozzle at

an angle to said surface of about 45°.

27. A method for treating a surface of a silicon-containing substrate as recited in claim 22 further comprising causing a relative rotational motion between said nozzle and said surface.

28. A method for treating a surface of a silicon-containing substrate as recited in claim 27, wherein said substrate is rotated around an axis of rotation, and further comprising moving said nozzle toward said axis of rotation, thereby providing relative rotational and translational motion between said nozzle and said substrate surface such that a spiral locus centered at a center of rotation is defined by said nozzle relative to said substrate surface.

29. A method for treating a surface of a silicon-containing substrate as recited in claim 28, further comprising mounting said nozzle on a radial arm with respect to said axis of rotation.

30. A surface of a silicon-containing substrate produced from said method of claim 16.

31. An apparatus for roughening a surface of a substrate comprising  
a base adapted to support said substrate during a roughening operation;  
a pressurized grit expulsion nozzle having a nozzle adapted to project grit against said surface of said substrate at a predetermined distance from, and at

an angle less than about 60° to, said surface of said substrate; and

a drive mechanism for rotating one or more of said base and said grit source to provide relative motion between said nozzle and said base during said roughening operation.

32. An apparatus for roughening a surface of a substrate as recited in claim 31, further comprising an arm extending outwardly from said center axis of said base upon which said nozzle is mounted, for controllably moving said nozzle between said center of said base and said periphery of said base such that providing relative rotational and translational motion between said nozzle and said base is capable of defining a spiral locus centered at a center of rotation coincident with said center of said substrate during said roughening operation.

33. An apparatus for roughening a surface of a substrate as recited in claim 31, further comprising a plurality of nozzles adapted to project grit against said surface of said substrate at a predetermined distance from, and at an angle less than or equal to about 60° to, said surface of said substrate.

34. An apparatus for roughening a surface of a substrate as recited in claim 31, wherein said nozzle is adapted to project grit against said surface of said substrate at a distance between about two inches to about ten inches.

35. An apparatus for roughening a surface of a substrate as recited in claim 34, wherein said nozzle is adapted to project grit against said surface of said substrate at a distance equal to about six inches.



36. An apparatus for roughening a surface of a substrate as recited in claim 31, wherein said pressurized grit source is positioned at an angle to said surface between about 40° and about 50°.

37. An apparatus for roughening a surface of a substrate as recited in claim 36, wherein said positioning comprises positioning said pressurized grit source at an angle to said surface of about 45°.